STILLÉ (Morton)

On Cyanosis
or Morbus Cæruleus.

ON

CYANOSIS;

OR,

MORBUS CÆRULEUS.

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Cyanosis, or Morbus Cæruleus, by either of which terms the disease we propose to treat of is sufficiently well designated, had not attracted, until of late years, much notice from medical writers. It is indeed true, that cases of the disease are to be found scattered through the periodical works of the last century, and that, as faithful portraits of its more striking features, they are unexceptionable; but we have to regret their imperfect description, in many instances, of structural alterations, and often the entire want of any account of these conditions. Had the value of these signs been always duly appreciated, the knowledge of the true pathology of the disease would not, perhaps, have been so long obscured, and the ingenuity expended in the support of fanciful hypotheses would have been more usefully employed in legitimate inferences from well ascertained facts. Several treatises on cyanosis, and chiefly from the pens of the French and German writers, are now extant, and have been regarded as containing all that was known of its pathology. The doctrines advocated in them have received a general and tacit assent, but we think that they will be found to be the offspring of a too narrow observation, and to embody speculative notions rather than sound principles.

The first approach to a more correct mode of investigation was made by M. Gintrac, of Bordeaux, who, in 1814, wrote an inaugural thesis upon this subject. Ten years after its publication it was again issued, in a more complete form, M. G. having, in the mean time, much extended his researches, and somewhat modified his opinions. His essay contains the history of 53 cases of cyanosis, collected by him from various works, some of which were rare, and difficult of access. M. Louis, in 1823, published a

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short treatise upon "The Free Communication between the Right and Left Cavities of the Heart," and founded his views of the pathology of the disease upon a consideration of eighteen cases.

From these cases, and from others which we have ourselves collated, it is now proposed, as preliminary to the examination of some controverted points, to give a brief general description of cyanosis, and its more important structural alterations, and while confining ourselves within the limits of well-attested facts, to avoid, for the moment, any assertion as to the relative frequency or value of either symptoms or lesions.

The sense in which we shall use the word cyanosis, is that of a blue discoloration of the skin and mucous membranes referable to some organic lesion of the heart or its great vessels. To define the disease more strictly would be a transgression of the present limits of our pathological knowledge, and however desirable the establishment of a positive and well supported cause of the disease may be, we shall be able, in the course of this article, to show into what serious errors and inconsistencies an over-hasty and too restricted a definition has led.

Cyanosis is met with chiefly in the earlier periods of life, occurring congenitally, or showing itself a few years after birth. When not congenital, its approach may be gradual, and the first indications of a disturbed circulation so slight as scarcely to attract notice; or, on the other hand, its invasion may be sudden, and complete discoloration be at once established. If, as is sometimes the case, cyanosis has first made its appearance in mature years, the attack is often referred by the patient to some antecedent injury, as a severe blow or fall. The extent and intensity of the discoloration vary in different cases, and at different periods in the life of the same individual. When it is but partial, it is most marked in the lining membrane of the mouth, upon the lips, cheeks, extremities of the fingers, and in those parts generally where the skin is delicate, and the capillary vessels numerous. The colour varies in its shades, from a mere livid tint to the most complete blackness, and is more marked in all violent efforts, and under the influence of strong moral impressions. If paroxysms occur, the discoloration will be deepest during their continuance, while in the remissions it may be but slight, or even entirely absent. The discoloured parts are also, at the same time, more or less œdematous. The external temperature of the body may be perfectly natural, or, on the other hand, so much lowered as to render the situation of the patient very distressing. In these latter cases the body seems incapable of receiving warmth, and the patient is chilled even in the hottest days of summer. The functions of digestion and secretion do not seem to be altered in any marked degree, but those of circulation and respiration exhibit the greatest deviations from the healthy standard. While the patient is in a state of repose, his breathing may be calm and regular. In some cases, however, the dyspnœa is habitual, but in all it is either induced or aggravated by any cause tending to excite the circulation. For this reason

persons affected with cyanosis, are either averse from, or incapable of exertion, and in them a vivid moral emotion will often bring on great oppression. Some are thrown by these causes into the most alarming paroxysms; the countenance becomes suddenly anxious and distressed, the surface livid, the respiration hurried and gasping, and the movements of the heart tumultuous and irregular. A state of syncope follows, in which the patient may lie for several hours. In some cases the paroxysms occur without any obvious exciting cause, and it is in one of them that the fatal issue takes place. The following lesions, defects, and alterations of structure of the heart and its great vessels, have been found in persons who have, during life, been affected with cyanosis.

1st. Dilatation and hypertrophy of the right cavities of the heart.

2d. Contracted state of the left cavities.

3d. A heart consisting of but one cavity.

4th. A heart with two cavities, an auricle and a ventricle.

5th. A heart with two auricles and one ventricle.

6th. Persistence of the foramen ovale, or a cribriform condition of the auricular septum.

7th. Deficiency of the ventricular septum at its base, or an entire absence of it.

8th. Dilatation of the aorta.

9th. A rudimentary condition of the pulmonary artery, contraction of it, adhesion of its valves, deficiency of one or more of them, cartilaginous or other growths at its orifice, or complete closure of it by membranous septa.

10th. Persistence of the ductus arteriosus.

11th. Contraction of the right auriculo-ventricular opening.

12th. Transposition of the aorta and pulmonary artery.

13th. The aorta and pulmonary artery arising from one ventricle.

14th. The aorta and pulmonary artery arising from a common trunk.

15th. The aorta giving off branches to the head and upper extremities, and the pulmonary artery forming the aorta descendens.

16th. The aorta giving off two pulmonary branches.

Some of these anatomical dispositions are often coincident, and in another place we shall endeavour to indicate their more frequent and important combinations; at present, however, it will be sufficient to note the great variety of pathological conditions that have been found in cases of the disease under consideration. The concurrent lesions of other organs, although well deserving of attention after the establishment of a well-founded theory of cyanosis, can be of little use in the investigation we are entering upon; for they are, for the most part, either secondary effects of the disturbance of the respiratory or circulatory functions, or mere accidental complications. The elements essential to the production of the disease manifestly reside in the heart and great vessels; to these, therefore, must our attention be mainly directed if we wish to discover its laws of causation.

The phenomena of cyanosis have been, by different writers, referred to one or other of the following causes.

1st. Obstruction to the return of the venous blood to the lungs.

2d. Presence of the venous blood in the general arterial system.

The first of these modes of explanation has been adopted by Louis, Berard, Bertin, and Ferrus among others, and has been regarded as an occasional cause by some of the advocates of the other view of the pathology of the disease. The class which takes this middle course is, perhaps, more numerous than either of those which maintain an exclusive doctrine, and whatever may be said of the consistency of thus admitting in turn one or other of two conflicting theories as may suit convenience, it certainly is a safe refuge from absolute error; for whichever may eventually be found to be incorrect, this class can never be *wholly* in the wrong. Among those who maintain the doctrine of the mixture of arterial and venous blood as the cause of cyanosis, may be mentioned, Morgagni, Senac, Corvisart, Caillot, Labat, Bouillaud, and particularly Gintrac, to whose industrious researches we have been much indebted in the present investigation. It may be mentioned here, that while the presence of venous blood in the general arterial system was considered by these writers the essential cause of cyanosis, they did not limit the mode of its production to any one anatomical condition of the heart; many, however, espousing their views, have thoughtlessly narrowed down the means of communication allowing the admixture of the blood to that one which is the most frequently met with, viz., an opening in the auricular septum, so that at present, and particularly in our own country, cyanosis and an open foramen ovale, are very generally regarded as inseparable. This untenable modification of the more general statement would hardly demand notice, were it not for its great prevalence, and the confidence with which remedial measures are sometimes based upon it.

Notwithstanding, however, all that has been written upon the subject, the pathology of cyanosis cannot yet be considered as resting upon stable grounds. The affection is one of rare occurrence, presenting a great variety in the character of its phenomena and *post-mortem* appearances. Manifestly, therefore, the history of one or two isolated cases can never entitle the observer to establish a general law of the disease. Nor, again, can the collation of a large number of recorded cases be of any value if deductions be made, not from the cases themselves, but from the opinions of those who have observed them. These last may be, and very often are, founded upon imperfect examinations; prejudice, ignorance, and many other causes, may render the conclusions obtained valueless, and one who, from such materials, should expect accurate results, could hardly fail of disappointment.

It is also evident, that although in the majority of instances some one symptom or lesion may have been found constant in its occurrence, yet its mere frequency is apart entirely from the importance it may claim in the history of the disease. For example—the striking discoloration of the skin

from which cyanosis takes its name, is entirely absent in some cases in which the structural alterations, regarded by some as the essential cause for its production, exist; and yet if the comparative frequency of their occurence were alone to be received as a sufficient test of the value of their relation to this symptom as cause and effect, we should be led into the error of admitting *that* to be essential to the production of the discoloration, which facts had proved was not so. It would not be difficult, indeed, to trace to its true cause the proneness to fall into this logical error; it requires but feeble persuasion to convince us of what we are already disposed to believe, and no one can be safe from the mistake of admitting a plausible explanation as a *true* one, if he be in search of arguments to sustain some preconceived and favourite theory. To consider dispassionately, and with equal care, all the facts presented to our observation is an indispensable requisite in any investi gation, and the most certain way of practically insuring it, is the adoption of some method of examination, by which the erroneous influence of even an unconscious leaning to any particular doctrine may be precluded. The plan pursued in the present essay will be found to present this advantage among others. All the attainable cases on record in the periodical works, and in the treatises on cyanosis have been collated, condensed, and subsequently arranged in a tabular form, the prominent points of interest in each being, at the same time, placed under their appropriate heads. In this manner upwards of 80 cases have been examined, the results of which we shall be enabled to present in the following pages.

The two theories of the pathology of cyanosis having been stated above let us now examine to what extent they are consonant with the facts thus obtained—and

1st. Of the presence of venous blood in the general arterial system.

The conditions necessary for this result, are, abnormal communications between the right and left cavities of the heart, or such a disposition of the principal vascular trunks as will allow their contents to intermingle. Whenever the black is brought into contact with the red blood, the colour resulting from the contamination is intermediate, or of a purple hue. If then, as the advocates of this doctrine maintain, there can be no discoloration of the skin, without this admixture of arterial and venous blood, we should always find, in cases where discoloration existed, some one of the communications abovenamed, for it is evident, that this explanation being an exclusive one, must, if true at all, be true of all cases.

In five cases, however, (the authorities for which are cited below,*) neither the foramen ovale nor the ventricular septum was open, nor did there exist any other passage by which the arterial and venous blood could commingle. Yet in *all* of these, there was the discoloration of the skin which

* Archives Gén. de Médecine, vol. viii. p. 594. Bouillaud, Malad. du Cœur, Obs. 77, p. 155. Edinburgh Med. and Surg. Journal, vol. liii. p. 552. Ibid. 1830. Lond. Med. and Phys. Journ., vol. xiv. p. 471.

is characteristic of cyanosis; in two it was partial in extent, in three complete. The other phenomena of the disease were likewise present. In a future part of this paper, these cases will be again taken up; the facts pertinent in this place, are those already stated, and they prove, 1*st*, *That cyanosis may exist without admixture of the blood.*

Again, the communications permitting this admixture, being of very frequent occurrence in cyanosis, it is rarely that cases are to be found, illustrating like the preceding, the want of relation between the disease, and its alleged pathological cause; as these communications vary, however, in their seat, and in the degree in which they will allow the access of the venous to the arterial blood, there should be a difference in the depth and extent of the cyanosis corresponding to the degree in which the blood is mingled. But numerous cases of the continued patescence of the foramen ovale are on record, in which, nevertheless, no symptoms of cyanosis had been manifested. Cases, also, of partial deficiency of the ventricular septum, without any accompanying discoloration of the skin, are of not infrequent occurrence. Setting aside these points altogether, as being open to some doubt in regard to the amount of blood vitiated, it will conduce more to a correct understanding of the actual relations of the discoloration with the mixture of the blood, if we examine those cases only in which the latter was not merely possible, but inevitable. In such, of course, the discoloration should bear a certain proportion in extent and intensity, to the degree in which the arterial was adulterated with the venous blood.

The four following cases are examples of this kind; we have annexed to each the amount of the discoloration as stated by those who observed them.

1. Ventricular septum open, aorta arising from the right ventricle,—no cyanosis except an occasional lividity of the lips.*

2. No pulmonary artery. Aorta arose from both ventricles, and gave off large bronchial branches. *Face only* cyanosed. Age 16 years.†

3. Heart with two cavities; the aorta and pulmonary artery arose from a common trunk. The lips livid upon the day of his birth, and that of his death. Age 7 days.‡

4. Heart with two cavities. Aorta gave off two pulmonary branches. Cyanosis slight and remitting. Age 3 days.§

In all of these cases, there was of necessity a thorough admixture of the blood, and a contamination thereby of the whole circulating fluid, altering its colour at the same time that it vitiated its character. So complete, indeed, was this vitiation, that it is difficult to understand how it was compatible with life. If a mere perforation of the auricular or ventricular septum were adequate, as is affirmed by some to the production of a general and marked discoloration of the skin, and the other phenomena of cyanosis, certainly we should have been warranted in anticipating at least an *equal* result in

* Lond. Med. and Phys. Journ., N. Ser. vol. vi. p. 548. † Ibid.

‡ Gintrac, Récherches sur la Cyanose, p. 44.

§ Farre, Pathol. Essay on Malform. of Heart, p. 2.

these instances. For if the effect bear any proportion to its alleged cause, the individuals in whom the lesions just named were found, should have offered the symptoms of cyanosis in the extreme. But, so far from this, it will be seen that in those cases affording the means for the most complete mixture of the blood there was the least discoloration. These four cases prove,

2*d. That there is no proportion between cyanosis, and the degree in which the blood is mixed.*

So great, indeed, is this disproportion, that these cases would render it highly probable that it may sometimes amount to an entire want of connection, but this is conclusively demonstrated by the two following cases.

1st. Foramen ovale open; pulmonary artery arose from both ventricles, gave off pulmonary branches, and formed the aorta descendens. The aorta gave off the arteries of the head and upper extremities, and joined the pulmonary artery by the ductus arteriosus; no cyanosis. Age 8 months.*

2d. Heart with two cavities; aorta and pulmonary arising from the ventricle; no cyanosis. Age 11 days.†

We are now entitled to proceed one step further, and to state the converse of the first proposition—viz:

3*d. That complete admixture of the blood may take place without cyanosis.*

M. Gintrac, who is, as we have before said, the most strenuous supporter of the doctrine of the mixture of the blood as the cause of cyanosis, encountered the difficulty presented by the cases just cited. Having met with several instances of the origin of the aorta over the ventricular septum, or in other words, from both ventricles, and in which cyanosis did not occur till several years after birth, he asks—"How shall we account for this late appearance of cyanosis?" "Must not the venous blood in these cases mingle with the arterial? Does there exist, in the early periods of life, any obstacle to this mixture? I think not. I am inclined to believe that, in new-born children, the two kinds of blood differ less, than at a more advanced age. The first inspirations produce in the organism a general stimulation; immediately the skin appears of a brilliant colour, the heart and vessels are strongly excited, the circulation of the blood is rapid, and from this activity, this velocity in the course of the fluid, result on the one hand, less considerable losses of the vivifying principles in the general capillary system, and on the other, a more prompt reparation in the capillary system of the lungs."

These sentiments have been quoted in M. G.'s own words, as it was feared that, if abbreviated, they might not be conveyed with sufficient precision. We would be reluctant to receive an hypothesis so gratuitous as this, as a satisfactory explanation of a well-established fact. That an increased velocity in the current of the blood is a reason why it should part with less of its vivifying principles, is a novel proposition in physiology, and one which,

* Farre, Pathol. Ess. p. 15. † Am. Journ. of Med. Sciences, Oct. 1843, p. 447.

we believe, will not stand the test of the most cursory examination. Is the nutrition of the young and growing being less active than the same process in the adult, and does not this function depend upon the surrender of what are vaguely termed "the vivifying principles?" What, in fact, is the object of the "prompt reparation" of the blood in the lungs if not to restore to it anew those "vivifying principles" which, in its route through the body, it has just yielded up? Adopting this hypothesis as a sufficient explanation of the absence of cyanosis in new-born children, where there was an unequivocal mixture of the two kinds of blood, it then became necessary for M. Gintrac to show how it was that cyanosis was *ever* congenital. He says that the action of the air on the lungs was, "in these cases, incomplete, imperfect, almost null. In most of them, in fact, the pulmonary artery was contracted, or even obliterated at its origin."

One of the effects of the contraction or closure of the pulmonary artery, supposing no compensation for the same to exist, and to which M. G. refers, would be, that a less amount of blood would reach the lungs. And the idea, which doubtless is here implied, is, that, therefore, the whole of the circulating fluid must be of a venous character, and give, in consequence, its colour to the skin. But, although the blood arrive at the lungs in a diminished quantity, there is no reason why the hæmatosis of this should not be complete; and the only influence that such a condition could exert upon the the character of the circulation, would be that it would diminish the mass of the arterial blood. M. Gintrac's views of congenital cyanosis involve then, not only an abandonment of his theory of the mixture of the blood, (which is, indeed, acknowledged by him to be insufficient,) but also of that of deficient hæmatosis, which is substituted in its place.

Having now seen the discrepancy existing between the occurrence of cyanosis, and the pathological conditions to which it has been referred, we shall here only subjoin one fact, which the cases we have collected have enabled us to determine, and which is, at the same time, confirmatory of the three positions already attained. If there be preternatural communications in the heart, or its great vessels, and the mixture of the blood has ever taken place, it must continue to do so. Moreover, the *degree* in which the arterial blood is deteriorated, will remain relatively the same; for although the heart may, under the influence of many causes, propel its contents with greater vigour, yet as this increased energy is shared alike by both sides, the discoloration can be no greater, as the amount of blood mingled is relatively the same as in a state of repose. Hence, it follows that there ought never to be any variation in the same individual of either the extent or intensity of the discoloration. It should be permanent. Such is, indeed, in many instances the case, a circumstance which, in another place, will be ascribed to what we consider its true cause. But in all cases in which the blood is mingled, the discoloration should be unvarying in its shade and extent, if upon that condition alone it depends. We have noted 77 cases in which

there were means for the mixture of the blood to take place. Of this number there were 29 in which the colour was constant in its extent or shade, or in which these particulars were not a subject of observation. In the remaining 48 there was a variation either in the depth, extent, and progress of the discoloration. In some the lips alone, in others these, the cheeks, the chin, and the extremities of the fingers and toes were cyanosed, and again in others the whole body was implicated; a light brown, a violet or livid hue, or the utmost blackness, were to be seen at different periods in the same individual, and these shades, passing into each other insensibly, while they, in some, did not permit the skin to return to its natural colour, in others allowed the remission to be complete and the skin natural, until the supervention of certain exciting causes reproduced the morbid appearance. The designation of the mode in which these causes act is reserved for another place; but from the evidence of these facts we are warranted in concluding, that as the mixture of arterial and venous blood is a cause acting with uniformity at all periods, it follows,

4th, *That the variation in the extent, depth, and duration of the discoloration is inexplicable by the doctrine of the mixture of the blood.*

It is presumed, that sufficient data have now been obtained to place the fact beyond cavil, that cyanosis cannot be referred to a mixture of arterial and venous blood as its cause. In estimating the value of these objections to the popular theory, let it be remembered that they claim no farther validity than that which belongs to the facts upon which they are based; the justice of the inferences we have made it is in the power of any one to verify. The rejection of this theory, however, does not impose upon us the necessity of adopting in its place any other with merely *plausible* pretensions; for as this has been abandoned only after full proof of its incorrectness, so can any other be entitled to reception only by resting its claim upon satisfactory grounds. Nor, indeed, could our inability to offer any adequate explanation of cyanosis, invalidate in the least the objections we have urged against the doctrine of the mixture of the blood, for the arguments by which this, or any other theory which shall account for its phenomena on distinct principles, is upheld, are independent; an insufficient refutation, therefore, on the one hand, or inadequate confirmation on the other, cannot necessarily imply the correctness of the opposing doctrine. Nevertheless, all will admit, that where two theories, both of which cannot be true at the same time, are proposed to account for certain morbid phenomena, if one of them can be proved, from careful examination, to be unsupported by the evidence of well-observed facts, there results in favour of the other a higher presumption, which may be the more easily elevated into demonstration, inasmuch as it is then sustained, not only by positive, but by negative proof. It has been mentioned before that there is but one other method of explaining the phenomena of cyanosis, viz:—that which ascribes it to a congestion of the general venous system, resulting from some obstruction in the right side of the heart,

or in the pulmonary artery, impeding the return of its blood to the lungs. It is now proposed to examine the basis upon which this doctrine rests, in order to determine whether or not it be entitled to our belief. We shall pursue the same mode of investigation in the examination of this theory as in that of the other; therefore, if *true*, the structural lesion which it assumes must fulfil the three following indications.

1st. That it shall account satisfactorily for the discoloration of the skin and the dyspnœa.

2d. That it shall be found in every case of cyanosis, or if not, there shall exist in its place some cause acting upon similar principles.

3d. That it shall never be found without the concurrence of cyanosis, or if it is, that a satisfactory explanation of the exception shall be given.

1st. *Does the contraction, obstruction, or imperforation of the pulmonary artery account satisfactorily for the discoloration of the skin and the dyspnœa?* The fact is a familiar one, that any cause impeding the return of the venous blood to the heart will produce a congestion in the veins exterior to the locality of the obstacle, which, according to the time the impediment remains, will manifest itself by giving a bluish or blackish tinge to the part. The appearance of the arm when, in the operation of bleeding, the ligature has been too tightly applied, is an example of partial cyanosis. If, however, the impediment be seated nearer the central organ of the circulation, in the air passages, as in croup, or in the lungs, as in pulmonary congestion, the cyanosis is then general, affecting first, however, the veins of the head and face, because of their proximity to the cause of the obstruction. Is it not, then, a reasonable inference, that, if the pulmonary artery, which is the grand outlet for the venous blood returning from every part of the body, be either obstructed at its orifice or narrowed in its calibre, the whole venous system must be consequently congested? Moreover, where these obstructions of the pulmonary artery exist, the capillary vessels must be constantly more or less distended, and it is highly probable that this state of dilatation must destroy, in some degree, their tonicity, and favour still more the stasis of venous blood in them. For this reason we should expect to find the discoloration chiefly manifest in the most vascular parts, and in those also which, being remote from the centre of the circulation, have the current in them proportionably sluggish. This, indeed, is consistent with general observation, and we find, accordingly, that the mucous membranes, the lips, the cheeks, and the ends of the fingers and toes, are the first to manifest the congestion. The pressure of venous blood upon the right side of the heart, resulting from an obstruction in the pulmonary artery, distends the cavities of that side, and from this distension, and the resistance to the due performance of their functions in consequence of the obstacle to the exit of the blood, they become often permanently dilated and hypertrophied. Of 53 cases of cyanosis in which the pulmonary artery was either contracted, obstructed or impervious, the condition of the *right cavities* was the subject of observation

in 36. The right auricle was dilated in 15 cases, and dilated and hypertrophied in 7. The right ventricle was dilated in 10, hypertrophied in 13, and dilated and hypertrophied in 12. The state of the *left cavities* of the heart was observed in 33 cases of the same series. The left auricle was contracted in 9, dilated with thinning in 1, and natural in 3. The left ventricle was contracted in 12, dilated in 3, thinned in 3, and natural in 3. We would state here, that we are not willing to rely upon these results, and especially on those which regard the condition of the left cavities of the heart, as exact, it being highly probable that in hasty or imperfect examinations, slight differences may have been exaggerated, or really valuable indications overlooked; yet the peculiar character of the deviation from the healthy standard, as exhibited in a diminution of the size of the left side, and a dilatation and hypertrophy of the right, is too remarkable to be passed by, and the dependence of the latter upon the obstruction to the passage of the blood through the pulmonary artery too probable to be admitted with much reserve. When considering the question whether or not the mixture of the blood was the essential cause of cyanosis, it was shown, from cretain cases then quoted, that there was such a disproportion between the phenomena of the discoloration, and the cause assigned for their production, that it was impossible to view them in the relation of cause and effect, and it was also shown, that the great variation in the extent and in the shade of the discoloration, was inexplicable by a cause acting with uniformity at all periods. Upon examining those cases in which the pulmonary artery was either contracted, obstructed, or impervious, with a view to ascertain how far the character of the discoloration was influenced by these conditions, we find, that of 53 cases of cyanosis, in which the former was observed, the latter was mentioned in 36. In *all* of these 36 cases there was a variation in its extent and intensity. Such a result is easily explained by the anatomical conditions. For it is well known that the colour is deepened and increased in extent under the influence of emotional causes, or of slight bodily excitement; and as the ordinary result of these is an increased activity of the circulation, and of the flow of blood through the pulmonary artery, an obstruction of this vessel would, of necessity, cause a turgescence of the whole venous system, corresponding in degree to the grade of the excitement, and producing a like variation in the discoloration of the skin.

Dyspnœa is a striking feature of cyanosis, and frequently recurs in paroxysms under the influence of mental or bodily excitement. If the blood be sent to the lungs in a quantity less than is required for the discharge of the function of hæmatosis, an attempt is made to compensate for this deficiency by an increased frequency of action; but if the movements of the heart be suddenly augmented in energy, there is, of necessity, a greater amount of blood thrown upon its right cavities, and the lungs expand, at the same time, more rapidly to receive it. The pulmonary artery, however, being obstructed, and the right cavities distended with the accumulated blood, its escape, except

in small quantities, is prevented, and the action of the lungs, thus rendered ineffectual, becomes like that of the heart, laboured and irregular, until at last syncope supervenes, and gives a short repose to those organs whose continued action was only adding, each moment, to the obstacle they were endeavouring to surmount. The state of the respiration was the subject of observation in 39 of the cases we have collected. In 3 of these the condition of the pulmonary artery was not observed, but in the remaining 36, in all of which the artery was either narrowed or obstructed, the dyspnœa was habitual, and speedily increased by movement or by moral impressions.

2*d*. *Is the contraction or partial or complete obstruction of the pulmonary artery to be found in every case of cyanosis, and if not, is there in those cases where it is wanting, an efficient cause of a similar character?*

There is one difficulty which presents itself on the very threshold of this inquiry. It may be thus simply stated. The common lesion of the pulmonary artery in cyanosis seems to have been unknown to a great number of observers, while that of the foramen ovale was known to all. The latter was then sought for in all cases of cyanosis, while the former may, in many, have been neglected. The popular opinion in regard to the efficiency of the open foramen in producing the disease was, no doubt, an additional reason why the state of the pulmonary artery was not observed in every case. We would not, perhaps, be warranted in taking it for granted, that, in all those cases in which all the pulmonary artery was not observed, the lesions abovementioned might, upon examination, have been found, although we would have good reason to infer this to have been the fact from the large number of cases, *similar in all respects*, in which the pulmonary artery was either contracted or obstructed. To avoid, however, introducing into estimates, which we wish to render as accurate as possible, an element, whose value we cannot ascertain, *those cases only* in which the pulmonary artery was *observed*, will form the basis upon which we shall proceed.

The pulmonary artery was observed in 62 cases. *In* 53 *of these, it was either contracted, obstructed, or impervious.* The remaining 9 cases presenting the phenomena of cyanosis without any one of these anatomical conditions existing, fall under the category of those cases, which, in accordance with a previous statement, must be examined in order to determine whether they act upon the same principle. Of these cases it is stated that the pulmonary artery was in—1 natural; 1 dilated; 1 aneurismal; 1 communicated with the aorta; 1 arose from the left ventricle; 2 given off by the aorta; 1 given off in two pulmonary branches by the aorta; 1 absent, but bronchial arteries large.

1st. In the first of these cases, the patient was a young man, who died at the age of 18 of an "insidious fever." During the last ten years of his life, he had been the subject of observation. His history, previous to that period, is entirely omitted, and thus one important fact, viz., the date of the attack, is left entirely to conjecture. The violet colour of the skin and lips

diminished or augmented every moment, according to his impressions, his attitude and movements, and the difficulty of his digestion or respiration. Upon *post-mortem* examination, evidences of sanguine congestion were found everywhere. The heart was large, and all its cavities filled with a semi-fluid black blood; the walls of the left ventricle were less than three lines in thickness, while those of the right ventricle were six lines thick, and the *columnæ carneæ* so much developed, as almost completely to obstruct the cavity of the ventricle. The auricular septum offered an opening of three lines in diameter. The effect of this almost complete obliteration of the cavity of the pulmonary ventricle can hardly be misunderstood. The amount of blood received by it could have been but very small, and there being provided no adequate compensation for the resistance thus opposed to the discharge of venous blood into its cavity, the whole of that resistance must have been felt throughout the entire venous system. The right ventricle being thus obstructed, any cause exciting the circulation, and throwing an increased quantity of blood upon it, must have cast it into violent, irregular and fruitless action, and consequently brought on the whole train of distressing symptoms which the patient experienced. The structural lesion of the right ventricle was, in fact, operative almost precisely in the same manner as would have been an obstruction to the passage of blood through the pulmonary artery. It is a matter of regret that the early history of this case has not been recorded, as, from the progression of the symptoms, some light might, perhaps, have been thrown upon the rare occurrence of hypertrophy of the right ventricle unconnected with other lesions of the heart.*

2d. A postilion, aged 57 years, received some violent blows upon the epigastrium, and during the three following weeks had dyspnœa, fainting fits and great pain in the part where the injury had been inflicted. These symptoms had subsided in a great degree when he received a new contusion in the same place. From that time he had palpitations, irregular pulse, suffocation on the least movement, œdema, ascites, &c. His face was livid or *violacé*. How long he survived this last injury is not mentioned. The heart was "voluminous," the right ventricle very much dilated and hypertrophied, and its *columnæ carneæ* as great as those usually found in the left ventricle. The right auriculo-ventricular opening was dilated, and the tricuspid valve proportionately enlarged. The cavity of the right ventricle was "enormous," its walls very thick, and the fleshy columns much developed. "The left auricle was dilated and thinned, the left auriculo-ventricular opening very much contracted, and the mitral valve thickened and rugose." The cavity of the left ventricle was so small as scarcely to receive a walnut, its walls being at the same time slightly thicker than natural. In the fossa ovalis there was an opening of an inch in diameter, its border thin, loose, and tendinous. The aorta was, at its origin, very much contracted

* Gintrac, Rech. sur la Cyanose, p. 98.

and the pulmonary artery dilated as far as its bifurcation, and its valves proportionately enlarged. It may be said that this cannot be quoted as a case of cyanosis, inasmuch as, previous to the reception of the injury above mentioned, the patient was in good health. But it is certainly sufficiently characteristic in the discoloration of the skin, and in the attendant symptoms, and so like in these to all the cases of acknowledged cyanosis in which the progress of the disease was gradual, that it may be ranked among them without the risk of violating any principle of arrangement. The symptoms recorded of this case are precisely those of all congestions of the venous system, where the cause of the obstruction is near the centre of the circulation. In this instance, the primary cause of the congestion may, we think, be found in the left side of the heart; the aorta being, as already stated, very much contracted, the left ventricle greatly lessened in capacity, and presenting, in the thickened and contracted state of the auriculo-ventricular opening, an important obstacle to the discharge of the aërated blood. The right side of the heart, as will be seen from the remarkable development of its muscular apparatus, was acting with unnatural energy, and thus the whole pulmonary circulation must have been consequently congested. This engorgement reacting, at the same time, upon the general venous system, this system was, in its turn, subjected to the influence of the remote cause in the left side of the heart, retarding the blood in its course, and preventing its free ingress into the lungs.*

3d. The case coming next in order is that in which the pulmonary artery was "aneurismal." The mode in which this condition would act in inducing venous congestion, is too evident to require illustration. The subject of it, aged 41 years, "was remarkable for the lividity of his complexion, the fulness of the vessels of the conjunctiva, and the thickness of his lips, which were, at the same time, nearly black. The respiration was so much disturbed that he could not pronounce two consecutive words, and he died in a state of suffocation."†

4th. In this case the pulmonary artery was prolonged directly into the aorta, and its branches were given off from its posterior aspect. The heart full of black blood, and the foramen ovale open. The child who was the subject of this report lived but twelve hours. Its colour, which soon after birth was seen to be black, became gradually less dark, until it assumed a bluish tinge; the difficulty of its respiration increasing, however, each moment, the skin became again perfectly black, and soon afterwards the child expired. The preservation, in this instance, of one of the characteristics of the fœtal circulation in the continuance of the ductus arteriosus, or (as stated in the report) the prolongation of the pulmonary artery into the aorta, and the failure to establish those new routes which the first act of inspiration should create, furnish us with a striking illustration of the

* Bouillaud, Malad. du Cœur, p. 562. † Gintrac, p. 64.

separate dependencies of uterine and extra-uterine existence. The placenta, it has often been remarked, holds the same relation to the fœtus as the lungs to the breathing child. But the function performed in the one case by the placenta, in the other by the lungs, is, in each, essential to the maintenance of vitality. If, then, after the circulation through the placenta has been cut off, the blood does not find access to its new respiratory organ, or if it be sent there only in part, life is entirely extinguished, or but imperfectly sustained. The blood, dammed up from its natural reservoirs, surcharges the general venous system, and the phenomena of asphyxia, persistent in this case on account of the remediless nature of the malformation, become fully established. The gradual decline in the depth of the discoloration, and its sudden recurrence in all its intensity, denote the struggle that nature was ineffectually making to fulfil her ordinary law.*

5th. In this case it is said that the pulmonary artery arose from the left ventricle. There existed, in fact, but one ventricle, the right being "rudimentary." The two auricles also constituted but one, as they formed "one large cavity without the least separation." The left auriculo-ventricular opening "was very much contracted, and its valve formed a cylindrical canal capable of receiving the index finger." The corresponding opening of the right side was "a little orifice of three lines in diameter, with a valve made of a fold of the lining membrane of the heart." The pulmonary artery was destitute of valves. A concurrence of such remarkable defects and alterations of structure of these could, of course, not have existed without a very serious interference with the general health. And the manner in which such disturbance was effected, cannot, we think, be a matter of doubt. By the morbid alteration of the valvular apparatus of the ostia venosa, both the systemic and pulmonary blood, in their returning currents, encountered an obstacle to their entrance into the ventricle. The result of this must have been a congestion of both systems, the signs of which, during life, were—a violet colour of the skin deepened by efforts in crying, difficult respiration, tumultuous and irregular movements of the heart, and anasarca of the abdominal parietes and the lower extremities. This child lived for three months and 23 days.†

6th and 7th. These two cases are introduced here on account of their being instances of the anomalous origin of the pulmonary artery, it being given off in both by the aorta. But they are examples also of slight contraction of that vessel, it being in one $\frac{5}{16}$ of an inch less in circumference than the aorta, and in the other its branches, as well as the pulmonary veins, were only one-half their usual size. The pathological influence of this contraction of the pulmonary artery could not have been other than that which would have been induced, had it arisen as usual from the right ventricle. The heart, in both these instances, consisted of only two cavities, an

* Gintrac, p. 150. † Ibid., p. 173.

auricle and a ventricle. Cited before in this essay, the *first* of these cases was adduced to show the great disproportion that existed between the degree in which the blood was mingled, and that of the discoloration, which amounted merely to a lividity of the lips, apparent on the day of the birth of the child, and the seventh day afterward, when it died.* In the other case the discoloration seems to have been more diffused, the difference being referable to the greater diminution in the calibre of the pulmonary vessels.†

8th. This case has also been cited before for the same purpose as the first of the two preceding, (page 30). The pulmonary branches received their blood only after it had first passed through the aorta. This vessel held, therefore, the same relation to them as a pulmonary artery, and would have fulfilled the same office for them, in a degree compatible, perhaps, with a more extended term of existence than that which the patient attained, had it not been so contracted at its origin as materially to interfere with its own proper functions, as well as to keep back a proper supply of blood from the lungs. The discoloration was, as stated before, slight and remitting.

9th. The last of the cases which we proposed to examine, is that in which it is stated that the pulmonary artery was absent, but its place supplied by bronchial arteries. The meagreness of the details furnished in the report of this case, and the ambiguity of some of them, may possibly lead us into erroneous deductions. We cannot, however, believe that the arteries here referred to under the name of bronchial, were those usually given off by the descending aorta; for this supposition is not required by a rational construction of the language used, nor is at all compatible with the fact of the individual who is the subject of the report having reached the age of 16 *years*, as there stated. We presume that the word bronchial was employed to denote the size and not the place of origin of the arteries spoken of, and that they might, with greater propriety, be termed *pulmonary*, and be considered as having been given off at the arch of the aorta. If this view be correct the case is similar to the one immediately preceding, in which the aorta is said to have given off two pulmonary branches, and the partial discoloration of the skin is equally explicable by the anatomical condition.‡ As the aorta arose from both ventricles, and therefore transmitted blood of a mixed character, this case has been before cited with reference to that fact, (page 30.)

In order to avoid fatiguing repetition, it has been our endeavour, in the notice of these cases, to be as brief as was consistent with a correct appreciation of their individual peculiarities. It is hardly necessary to revert in the present place to the necessity that called for their examination. It will be remembered that, having in a previous part of this article examined, by means of the cases we had collected, the doctrine which ascribed cyanosis to

* Gintrac, p. 44. † Ibid., p. 56.

‡ Lond. Med. and Phys. Journ., vol. vi. p. 548.

a mixture of the venous with the arterial blood, it was considered that there was adequate proof of its invalidity; in looking, therefore, for some lesion which should be an invariable coincident of cyanosis, and at the same time, an efficient cause of its production, it was found that the contraction of the pulmonary artery was so constant in its occurrence that the few cases in which it was not found might, perhaps, upon examination, be discovered to act upon similar principles in the causation of the ordinary phenomena of the disease. The nine cases which we have just examined, were the only ones in which the pulmonary artery was not contracted, obstructed, or impervious. But in nearly all of them much more important alterations of structure than a mere contraction of the pulmonary artery were found to exist, and it was then necessary to examine whether the conditions presented by them were such as were capable of producing venous congestion, or, in other words, of operating on the same principle as did the contraction of the pulmonary artery.

It will now be seen, that so far from affording any ground for an objection to the doctrine that the essential characteristics of cyanosis are constituted by general venous congestion, they do on the contrary confirm it, and prove that there is no *one* lesion which is entitled to be considered as the anatomical character of cyanosis, but that it depends simply upon any cause which, acting at the centre of the circulation, will produce a stasis of venous blood in the capillary system. Cases of cyanosis, therefore, may be met with in which no one of the anatomical dispositions above enumerated shall be found; or, again, the lesion upon which the disease may really depend, shall be so recondite as to elude observation; but as it is evident that the variety of malformations and alterations of structure may be almost without limit, and that many more than those we have been able to gather may be productive of congestion, such instances will, probably, only bring additional proof of the correctness of the conclusions that previous facts have afforded. We are now prepared to state that the second requirement that was proposed as necessary for the establishment of any theory of cyanosis, is fulfilled by the facts that have been adduced, viz.

2*d*. *That the alleged cause shall be found in every case of cyanosis, or if not, there shall exist in its place some cause acting upon similar principles.*

It will be seen that the next requirement, viz:

3*d*. *That the alleged cause shall never be found without the concurrence of cyanosis*, is met by the same facts which were brought forward under the preceding head. We have found, in fact, no one case of contraction, obstruction or imperforation of the pulmonary artery in which there was not cyanosis.

If *contraction of the pulmonary artery* be now taken as the type of all the lesions that may produce a cyanosis, we are entitled to state,

1*st*. *That it is present in every case of cyanosis.*

2*d*. *That it never exists without the concurrence of cyanosis;* and

3*d*. *That it is an adequate explanation of the most important phenomena of the disease.*

The question has been agitated, and mostly in a speculative manner, whether or not the contraction and obstruction of the pulmonary artery were congenital lesions. As it has been previously stated that in all the cases of cyanosis which we had collected, this lesion was uniformly found (9 cases excepted, in which for the most part, there was a malformation of the heart), it is hardly necessary to add, that in all those which were congenital, either contraction or partial or complete obstruction must have existed from birth. In order, however, that direct evidence on this point may not be wanting, the following statement is subjoined.

In 28 cases of congenital cyanosis the pulmonary artery was contracted, obstructed, or impervious.

It was found to be impervious at its orifice, or contracted and obstructed, in those who died at the following ages:

Impervious in 1 at 7 days.	Contracted or obstructed in 1 at 6 years.
1 at 13 days.	3 at 8 "
1 at 23 days	1 at 9 "
1 at 5 weeks.	2 at 10 "
1 at 6 weeks.	2 at 11 "
1 at 8 months.	1 at 14 "
1 at 11 months.	2 at 16 "
1 at 15 months.	1 at 17 "
1 at 1 year.	1 at 18 "
Contracted or obstructed in 1 at 5 months.	1 at 29 "
1 at 5 years.	1 at 57 "

A few facts in regard to the relative proportion of the two sexes which were the subjects of cyanosis, the number of cases in which it was congenital, and the duration of life, may here be added.

Of 72 cases of cyanosis in which the sex was mentioned, 41 were male, 31 female; of 71 cases in which the date of the attack was observed, it was congenital in 40, and occurred in the remaining 31 non-congenital cases at various periods after birth.

The following table will show the duration of the disease in all the congenital cases.

7	patients died within 23 days after birth.
3	" " between 23 days and 10 weeks.
7	" " " 10 weeks and 1 year.
10	" " " 1 year and 10 years.
10	" " " 10 years and 20 years.
1	patient " at 29 years.
1	" " " 35 "
1	" " " 57 "

It having been the sole object of the present inquiry, to ascertain *the laws of the causation of cyanosis*, and at the same time, to do this in a manner

which, while it precluded speculative discussion, should place the results obtained upon a basis furnished by statistical evidence, it does not come within its proper scope to notice those other phenomena of the disease, which, although usually embraced in its description, are yet not to be deemed its essential constituents. Direct and decisive proof has been throughout insisted upon, and such the points alluded to are not capable of receiving. The writer will be amply repaid for the labour expended in the collection and preparation of the cases requisite for the foregoing investigation, if the results derived from them shall in any degree contribute to the furtherance of exact and useful medical knowledge.